ABSTRACT

Liu, Yu. M.S.M.E., Purdue University, May 2016. Modifications to Johanson's Roll Compaction Model for Improved Relative Density Predictions. Major Professor: Carl Wassgren, School of Mechanical Engineering.

Johanson's roll compaction model [J.R. Johanson, A rolling theory for granular solids, ASME Journal of Applied Mechanics E32 (1965) 842–848] is modified to improve its predictions of a compacted ribbon's relative density. Previous work has shown that the maximum roll pressure and ribbon relative density predicted by the Johanson model are not only larger than those predicted from finite element method (FEM) simulations, but also unphysical in some cases. This over-prediction is due to a one-dimensional flow assumption in the Johanson model. Real velocity profiles have been shown to be non-uniform.

Johanson's analysis is modified in this work to include a mass correction factor to account for the improper one-dimensional flow assumption, similar to what was proposed by Bi et al. [M. Bi, F. Alvarez-Nunez, F. Alvarez, Evaluating and modifying Johanson's rolling model to improve its predictability, J Pharm Sci. 103 (2014), 2062-2071]. Unlike Bi et al.'s work, however, an empirical curve fit for the mass correction factor is included in the current analysis. Two fitting parameters, found from an on-line measurement of the roll force and minimum roll gap, are used to determine the mass correction factor at the minimum gap width.

Predictions of the average relative density at the minimum gap width from the modified Johanson model are compared to predictions from two-dimensional FEM models and the errors are found to be around 5% of the FEM predictions. The unmodified Johanson model over-predicts the FEM results by around 50%. Comparisons to published experimental data also show good agreement. This modified Johanson model can be used in control schemes to provide much better estimates of ribbon relative density in roll compaction operations.